

# Pipeline Pressures and Sectoral Inflation Dynamics<sup>1</sup>

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<sup>1</sup>Disclaimer: The views expressed in this paper are those of the authors and do not necessarily reflect the views of the National Bank of Belgium, the European Central Bank, the Eurosystem, KBC Group or any other institutions to which the authors are affiliated.

# Outline

Motivation

What do we know so far?

The model

    Overview of the model

    Estimation details

Results

    Test prevalence pipeline pressures

    Comparison dfm vs. structural model

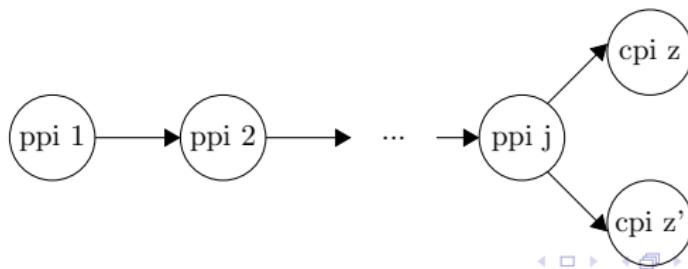
    Volatility & Persistence

    Additional results

Concluding remarks

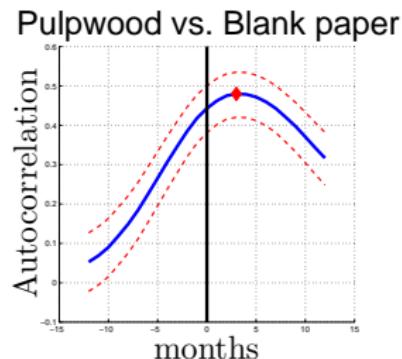
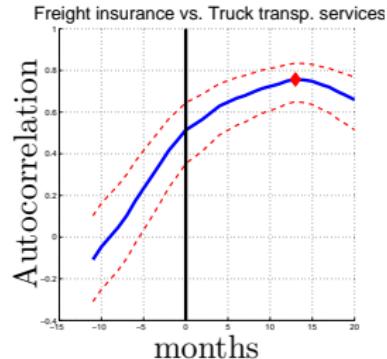
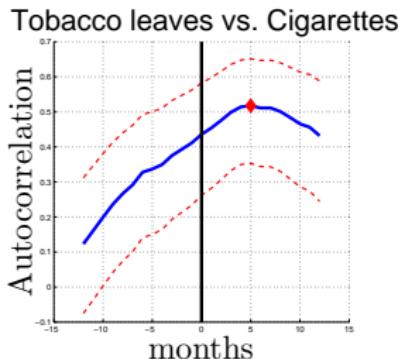
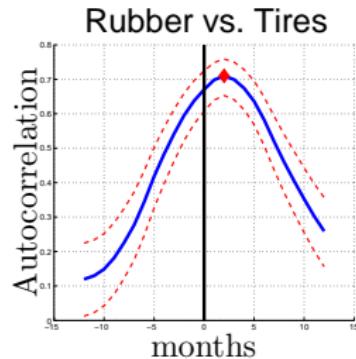
# Motivation (i): Pipeline pressures

- ▶ Pipeline pressures
  - “Pipeline pressures have built up in some sectors in early stages of the production and pricing chain.” (*ECB, 2017*)
  - “Producer price data of the construction sector were also consistent with a moderation of pressures in the inflation pipeline.” (*Daiwa capital markets, 2017*)
  - “The figures suggested price pressure at the start of the inflation pipeline may not be building as fast as the BoE feared.” (*Reuters, 2007*)
- ▶ The build-up of ppi inflation in sector  $j$  at time  $t$  affects ppi in sector  $j'$  at  $t'$  (and ultimately consumer price inflation).
- ▶ Production view on inflation



## Motivation (ii): Pipeline pressures

- Micro-level PPI's/CPI's often represent sequential input



## Motivation (iii): Pipeline pressures

- This paper: study implications of pipeline pressures for inflation dynamics.
- Focus on two properties of inflation data:
  1. Persistence
  2. Volatility

# Plan

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# What do we know so far?

- ▶ Persistence and volatility have been studied before
  - Landmark paper: Boivin et al. (AER, 2009)
- ▶ Dynamic factor model (dfm)

$$\text{Disaggregate index: } \pi_{it} = \underbrace{\lambda'_i f_t}_{\substack{\text{Common} \\ \text{component} \\ \text{Aggregate} \\ \text{shocks}}} + \underbrace{\epsilon_{it}}_{\substack{\text{Residual} \\ \text{Sector} \\ \text{specific} \\ \text{shock}}}$$
$$\text{Headline index: } \pi_t = \mathbf{w}' \boldsymbol{\Lambda} \mathbf{f}_t + \mathbf{w}' \boldsymbol{\epsilon}_t$$

- ▶ Two-way decomposition
  1. Volatility:  $\frac{\sigma^2(\lambda'_i f_t)}{\sigma^2(\pi_{it})}$  vs.  $\frac{\sigma^2(\epsilon_{it})}{\sigma^2(\pi_{it})}$
  2. Persistence:  $\rho(\lambda_i f_t)$  vs.  $\rho(\epsilon_{it})$
- ▶ 4 stylized facts

# What do we know so far?

STYLIZED FACTS; DISAGGREGATE INFLATION ( $\pi_{it} = \boldsymbol{\lambda}'_i \mathbf{f}_t + \epsilon_{it}$ )

		Consumer prices		Producer prices	
		Mean	Median	Mean	Median
Persistence	$\rho(\epsilon_{it})$	0.07	0.12	0.14	0.16
	$\rho(\boldsymbol{\lambda}'_i \mathbf{f}_t)$	0.57	0.62	0.44	0.51
Volatility	$100 \times \frac{\sigma^2(\epsilon_{it})}{\sigma^2(\pi_{it})}$	63.00	61.69	63.54	65.07
	$100 \times \frac{\sigma^2(\boldsymbol{\lambda}'_i \mathbf{f}_t)}{\sigma^2(\pi_{it})}$	37.00	38.31	36.45	34.92

STYLIZED FACTS; HEADLINE INFLATION ( $\pi_t = \mathbf{w}' \boldsymbol{\Lambda} \mathbf{f}_t + \mathbf{w}' \boldsymbol{\epsilon}_t$ )

		Consumer prices		Producer prices	
		Mean	Median	Mean	Median
Persistence	$\rho(\mathbf{w}' \boldsymbol{\epsilon}_t)$	-0.04	-0.08	-0.08	-0.08
	$\rho(\mathbf{w}' \boldsymbol{\Lambda} \mathbf{f}_t)$	0.70	0.37	0.37	0.37
Volatility	$100 \times \frac{\sigma^2(\mathbf{w}' \boldsymbol{\epsilon}_t)}{\sigma^2(\pi_t)}$	35.54	26.35	26.35	26.35
	$100 \times \frac{\sigma^2(\mathbf{w}' \boldsymbol{\Lambda} \mathbf{f}_t)}{\sigma^2(\pi_t)}$	64.46	73.65	73.65	73.65

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1. Stylized fact (1): Persistence disaggregate inflation

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1. Stylized fact (1): Persistence disaggregate inflation
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1. Stylized fact (1): Persistence disaggregate inflation
2. Stylized fact (2): Volatility disaggregate inflation
3. Stylized fact (3): Persistence headline inflation

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1. Stylized fact (1): Persistence disaggregate inflation
2. Stylized fact (2): Volatility disaggregate inflation
3. Stylized fact (3): Persistence headline inflation
4. Stylized fact (4): Volatility headline inflation

# What we do

- ▶ Traditional: two-way view on the data:

$$\pi_{it} = \underbrace{\lambda'_i f_t}_{\text{Aggregate shocks}} + \underbrace{\epsilon_{it}}_{\text{Sector } i \text{ shock}}$$

- ▶ Sector shocks → pipeline pressures → comovement
- ▶ So  $\lambda'_i f_t$  confounds two types of shocks (Foerster e.a, 2011):
  - Aggregate shocks
  - Sector-specific shocks, through pipeline pressures
- ▶ Non-trivial implications on stylized facts
  - ▶  $\rho(\lambda'_i f_t)$  reflects aggregate shocks and sectoral shocks
  - ▶  $\frac{\sigma^2(\lambda'_i f_t)}{\sigma^2(\pi_{it})}$  reflects aggregate shocks and sectoral shocks
- ▶ This paper: three-way decomposition:

$$\pi_{it} = \underbrace{\alpha_t(\pi_i)}_{\text{Aggregate shocks}} + \underbrace{\beta_t(\pi_i)}_{\text{Sector } i \text{ shocks}} + \underbrace{\gamma_t(\pi_i)}_{\text{Pipeline Pressures}}$$

# What we do

In a nutshell, what we do

1. Infer pipeline pressures from the data
  - ▶ Structural model
2. Verify empirical relevance
  - ▶ Bayes factor
3. Verify difficulties of the dfm to correctly disentangle pipeline pressures from aggregate shocks
  - ▶ Compare model decomposition with dfm decomposition
4. Assess impact of pipeline pressures on stylized facts

# Preview main findings

## 1. Persistence

- ▶ Important source of persistence
- ▶ Pipeline pressures (often) take time to build

## 2. Volatility

- ▶ Headline inflation: 21% (ppi) and 28% (pce)
- ▶ Disaggregate price inflation
  - 40% for Healthcare (pce index) vs. 0.87% for Agriculture & Forestry (ppi index).
  - Generally larger for consumer prices than for producer prices
  - Within producer prices; larger for downstream sectors than upstream sectors

## 3. Pipeline pressures: Varying size/composition throughout 1970Q1 – 2007Q4 in U.S. data.

# Literature

Crossroads of multiple literatures

## 1. Origins inflation persistence:

- ▶ Basu (AER, 1995); Blanchard (AER, 1982); Huang et al. (AER, 2006); Carvalho (JME, 2006); etc.

## 2. Origins inflation volatility:

- ▶ Bouakez (EER, 2014); Schoenle et al. (2017, 2018); etc.

## 3. Dynamic factor model decompositions:

- ▶ Boivin et al. (AER, 2009); Mackowiak et al. (JME, 2009); Auer et al. (JME, 2018); Kaufmann and Lein (EER, 2013); Andrade and Zachariadis (JIE, 2016); etc.

## 4. Propagation mechanisms.

- ▶ Acemoglu et al. (AER, 2017; EM, 2012); Di Giovanni et al. (EM, 2014); Fahri & Baqaee (EM, 2018); Ozdagli & Weber (EM, 2018); etc.

## 5. Extend class of multisector dsge models:

- ▶ Bouakez et al. (EER, 2014; IER, 2009); Carvalho (2006, AER); Dixon et al. (BoE, 2007); etc.

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# Overview of the model (i)

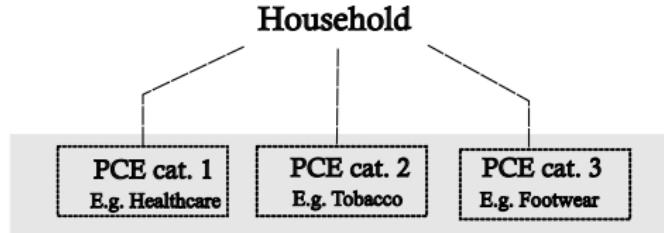
- ▶ Shocks

- ▶ Type: standard set of shocks (Workhorse dsge models)
- ▶ Level: aggregate and sectoral

TYPE AND LEVEL OF SHOCKS

Type	Level of shock	
	Aggregate	Sectoral
Monetary policy shock	X	—
Risk shock	X	—
Aggregate demand shock	X	—
Productivity shock	X	X
Price markup shock	X	X
Wage markup shock	X	X
Investment shock	X	X

## Overview of the model (ii)



## Overview model (ii): Household

Maximize utility (household member  $h$  in sector  $j$ )

$$\mathcal{U}_{j,t}(h) = \sum_{s=t}^{\infty} \beta^{s-t} \left( \frac{(C_t(h) - \chi C_{t-1}(h))^{1-\sigma}}{1-\sigma} - \frac{L_{jt}(h)^{1+\varphi}}{1+\varphi} \right)$$

s.t. budget constraint

$$P_t C_t + \frac{B_t}{R_t Z_{b,t}} = \sum_{j=1}^J \int_{\bar{\mu}_{j-1}}^{\bar{\mu}_j} L_{jt}(h) W_{jt}(h) dh + B_{t-1} + D_t - P_t T_t$$

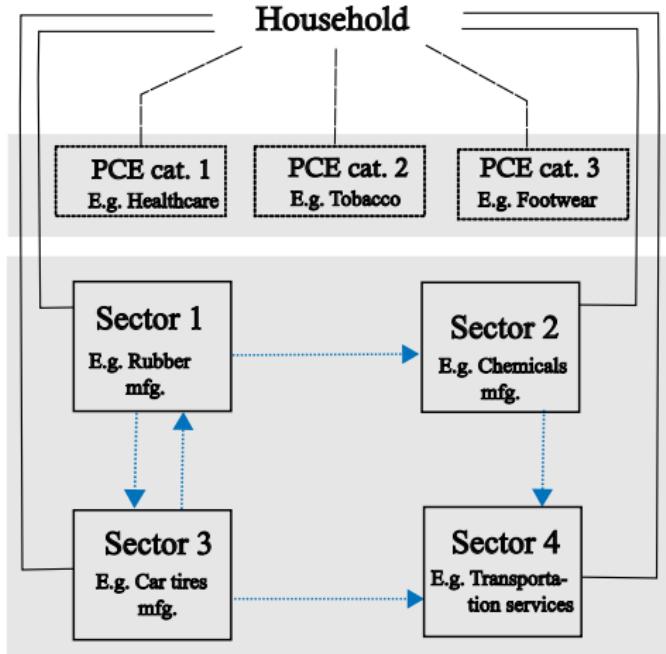
Aggregate consumption bundle

$$C_t = \left( \sum_{z=1}^Z \xi_z^{\frac{1}{\nu_c}} C_{zt}^{1-\frac{1}{\nu_c}} \right)^{\frac{\nu_c}{\nu_c-1}} ; \quad \sum_{z=1}^Z \xi_z = 1; \xi_z \in [0, 1]$$

Product level consumption bundle

$$C_{zt} = \left[ \int_0^1 C_{zt}(q)^{\frac{1}{1+\epsilon_{c,z,t}}} dq \right]^{1+\epsilon_{c,z,t}}; \quad P_t = \left( \sum_{z=1}^Z \xi_z P_{zt}^{1-\nu_c} \right)^{\frac{1}{1-\nu_c}}$$

## Overview of the model (iii)



## Overview model (iii): Intermediate goods producers

Production

$$Y_{jt}(f) = Z_{p,t} Z_{p,j,t} \underbrace{N_{jt}(f)^{\phi_j^n}}_{\text{Labour}} \underbrace{M_{jt}(f)^{\phi_j^m}}_{\text{Intermediates}} \underbrace{K_{jt}(f)^{\phi_j^k}}_{\text{Capital}} - \Phi_j(f)$$

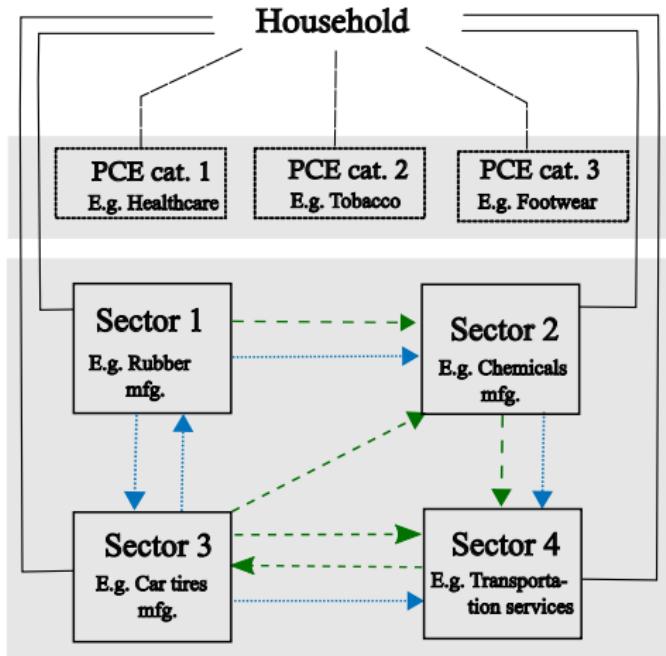
$$M_{jt}(f) = \left( \sum_{j'=1}^J \omega_{jj'}^{\frac{1}{\nu_m}} M_{jj't}(f)^{\frac{\nu_m-1}{\nu_m}} \right)^{\frac{\nu_m}{\nu_m-1}}$$
$$M_{jj't}(f) = \left( \int_0^1 M_{jj't}(f, f')^{\frac{1}{1+\epsilon_{m,j',t}}} df' \right)^{1+\epsilon_{m,j',t}}$$

Set producer prices (ppi's)

Calvo price stickiness  $\alpha_j^{ppi}$

IO structure  $\Omega$  creates role for pipeline pressures

## Overview of the model (iv)



## Overview model (iv): Capital goods producers

Law of motion capital

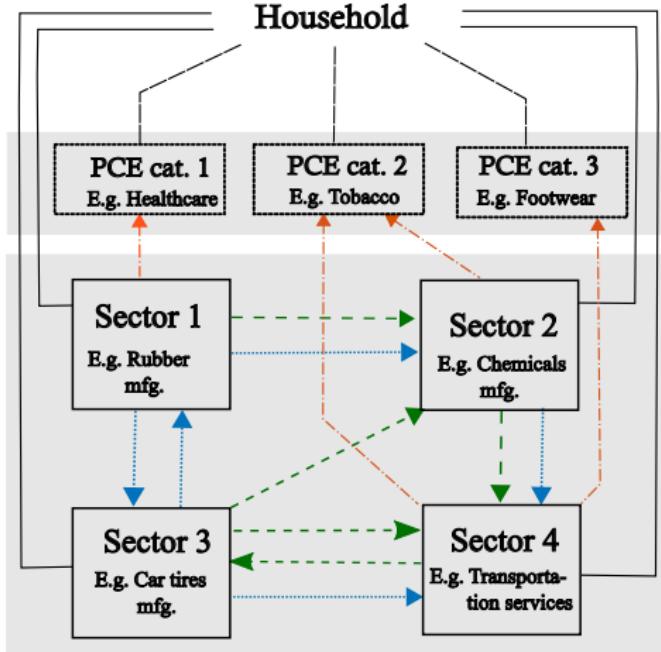
$$\tilde{K}_{jt+1}(g) = \left(1 - \Delta(U_{jt}(g))\right) \tilde{K}_{jt}(g) + Z_{i,t} Z_{i,j,t} \left(1 - S\left(\frac{I_{jt}(g)}{I_{jt-1}(g)}\right)\right) I_{jt}(g)$$

Investment

$$I_{jt}(g) = \left( \sum_{j'=1}^J \psi_{jj'}^{\frac{1}{\nu_i}} I_{jj't}(g)^{\frac{\nu_i-1}{\nu_i}} \right)^{\frac{\nu_i}{\nu_i-1}}$$
$$I_{jj't}(g) = \left( \int_0^1 I_{jj't}(g, f)^{\frac{1}{1+\epsilon_{p,j',t}}} df \right)^{1+\epsilon_{p,j',t}}$$

Investment flow structure  $\Psi$  creates role for pipeline pressures

# Overview of the model (v)



# Overview of the model (v): Final goods producers

Production

$$Y_{zt}(q) = \varsigma M_{zt}(q) - \Phi_z(q)$$

$$M_{zt}(q) = \left( \sum_{j=1}^J \kappa_{zj}^{\frac{1}{\nu_f}} M_{zjt}(q)^{\frac{\nu_f-1}{\nu_f}} \right)^{\frac{\nu_f-1}{\nu_f}}$$

$$M_{zjt}(q) = \left( \int_0^1 M_{zjt}(q, f)^{\frac{1}{1+\epsilon_{p,j,t}}} df \right)^{1+\epsilon_{p,j,t}}$$

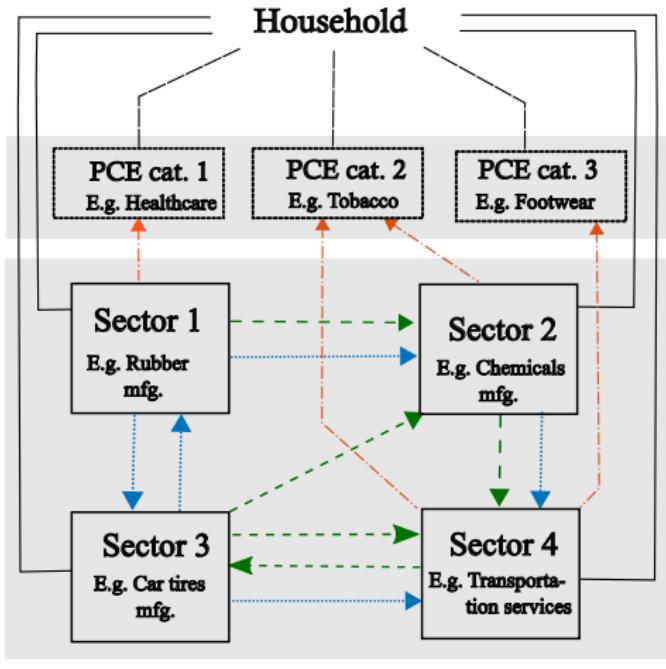
Set consumer prices (pce's)

Calvo price stickiness  $\alpha_z^{pce}$

Flow structure  $\mathbf{K}$  creates role for pipeline pressures (from producer prices to consumer prices)

ppi's and pce's need not coincide

## Overview of the model (vi)



## Overview model (vii): Decomposition

Disaggregate ppi inflation

$$\pi_{jt}^{ppi} = \underbrace{\alpha_t(\pi_j^{ppi})}_{\text{Aggregate shocks}} + \underbrace{\beta_t(\pi_j^{ppi})}_{\text{Sector } j \text{ shocks}} + \underbrace{\gamma_t(\pi_j^{ppi})}_{\text{Pipeline Pressures}}$$

TYPE AND LEVEL OF SHOCKS

Type	Level of shock		
	Aggregate	Micro	
		ppi $j$	ppi $-j$
Monetary policy shock	X	—	—
Risk shock	X	—	—
Aggregate demand shock	X	—	—
Productivity shock	X	X	X
Price markup shock	X	X	X
Wage markup shock	X	X	X
Investment shock	X	X	X

## Overview model (vii): Decomposition

Disaggregate ppi inflation

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Wage markup shock	X	X	X
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## Overview model (vii): Decomposition

Disaggregate ppi inflation

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## Overview model (vii): Decomposition

Disaggregate ppi inflation

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Wage markup shock	X	X	X
Investment shock	X	X	X

## Overview model (vii): Decomposition

Disaggregate pce inflation

$$\pi_{zt}^{pce} = \underbrace{\alpha_t(\pi_z^{pce})}_{\text{Aggregate shocks}} + \underbrace{\beta_t(\pi_z^{pce})}_{\text{Sector } z \text{ shocks}} + \underbrace{\gamma_t(\pi_z^{pce})}_{\text{Pipeline Pressures}}$$

TYPE AND LEVEL OF SHOCKS

Type	Level of shock		
	Aggregate	Micro	
		pce $z$	pce $-z$
Monetary policy shock	X	—	—
Risk shock	X	—	—
Aggregate demand shock	X	—	—
Productivity shock	X	X	X
Price markup shock	X	X	X
Wage markup shock	X	X	X
Investment shock	X	X	X

# Estimation details

- ▶ Dimensions of the model
  - ▶ 7 sectors: Agriculture, Mining, Utilities, Construction, Manufacturing, Services, Public Sector
  - ▶ 4 final consumption goods: Durables, Non-Durables, Services, Public sector goods
- ▶ Partly calibrated
  1. Behavioural parameters  $\{\beta, \sigma, \dots\}$
  2. Structure of the economy  $\{\Omega, \Psi, K, \alpha^{ppi}, \alpha^{pce}, \alpha^w, \dots\}$
- ▶ Partly estimated: Bayesian techniques using micro & macro data on the US economy 1970Q1:2007Q4.

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# Test empirical relevance of pipeline pressures

- ▶ Empirical relevance of pipeline pressures?
  - ▶ PPI sector  $j$  relevant for PPI of sector  $j'$ ?
  - ▶ PPI sector  $j$  relevant for PCE of product  $z$ ?
- ▶ Compare 2 models (with/without pipeline pressures)
- ▶ Bayes factor to test for relevance pipeline pressures

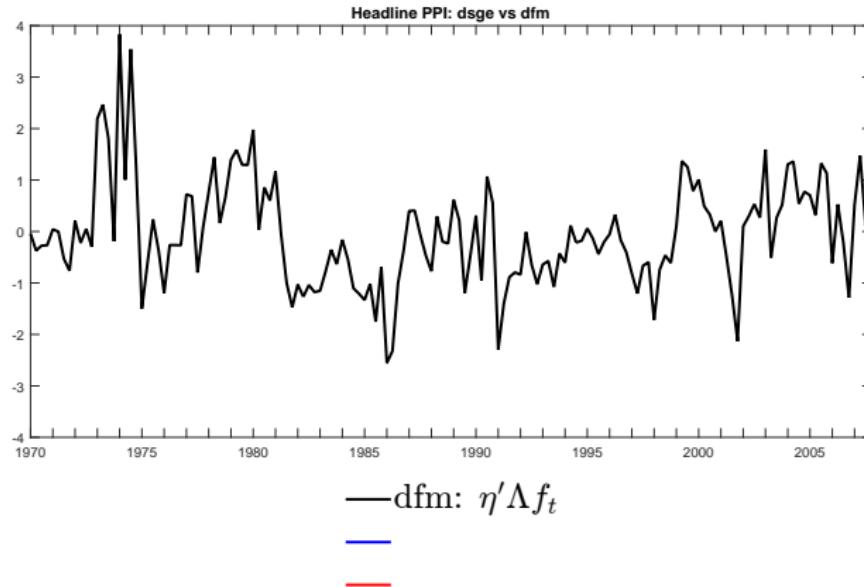
$\omega_{j'j} = \psi_{j'j} = 0$

BAYES FACTOR: PIPELINE PRESSURES

	Agriculture $j = 1$	Mining $j = 2$	Utilities $j = 3$	Construction $j = 4$	Manufacturing $j = 5$	Services $j = 6$	Public Sector $j = 7$
$\frac{\mathcal{L}(y_T   \mathcal{M})}{\mathcal{L}(y_T   \mathcal{M}_{\omega_{j'j}=0, \psi_{j'j}=0})}$							
$j' = 1$	Agriculture		1.00	$8 \times 10^3$	5.87	160.82	19.6
$j' = 2$	Mining	1.00		7.56	7.56	$2 \times 10^3$	$1 \times 10^3$
$j' = 3$	Utilities	1.00	$7 \times 10^4$		0.05	15.66	$2 \times 10^7$
$j' = 4$	Construction	$1 \times 10^4$	14.95	7.4		$2 \times 10^9$	1.00
$j' = 5$	Manufacturing	23.42	3.39	9.65	$1 \times 10^4$		$2 \times 10^7$
$j' = 6$	Services	8.63	10.06	21.32	0.00		$6.15$
$j' = 7$	Public Sector	7.58	$1 \times 10^7$	$9 \times 10^6$	106.08	15.57	$3 \times 10^6$
$\frac{\mathcal{L}(y_T   \mathcal{M})}{\mathcal{L}(y_T   \mathcal{M}_{\kappa_{zj}=0})}$							
Panel A							
$z = 1$	Durables	5.56	3.45	7.53	1.00	346.31	96.23
$z = 2$	Non-Durables	3.44	4.32	7.56	1.00	$2 \times 10^7$	$7 \times 10^4$
$z = 3$	Services	3.75	3.55	9.18	7.57	6.65	$2 \times 10^{28}$
$z = 4$	Public sector	1.00	1.00	5.80	1.00	1.00	0.00
Panel B							

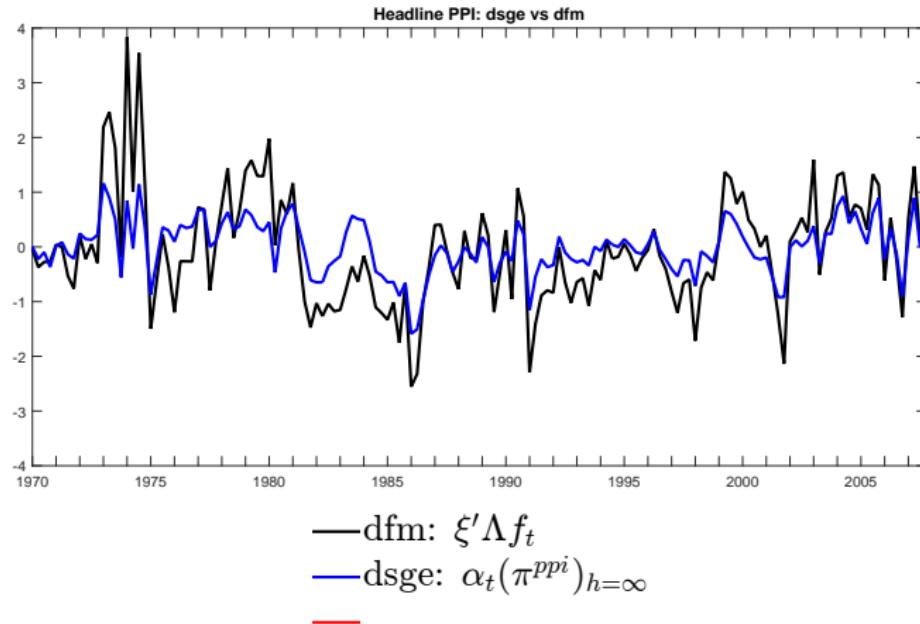
# Comparison dfm vs. structural model

- Decompose U.S. inflation
  - Factor model:  $\pi_{it} = \boldsymbol{\lambda}'_i \mathbf{f}_t + \epsilon_{it}$
  - Structural model:  $\pi_{it} = \boldsymbol{\alpha}_t(\pi_i) + \boldsymbol{\beta}_t(\pi_i) + \gamma_t(\pi_i)$



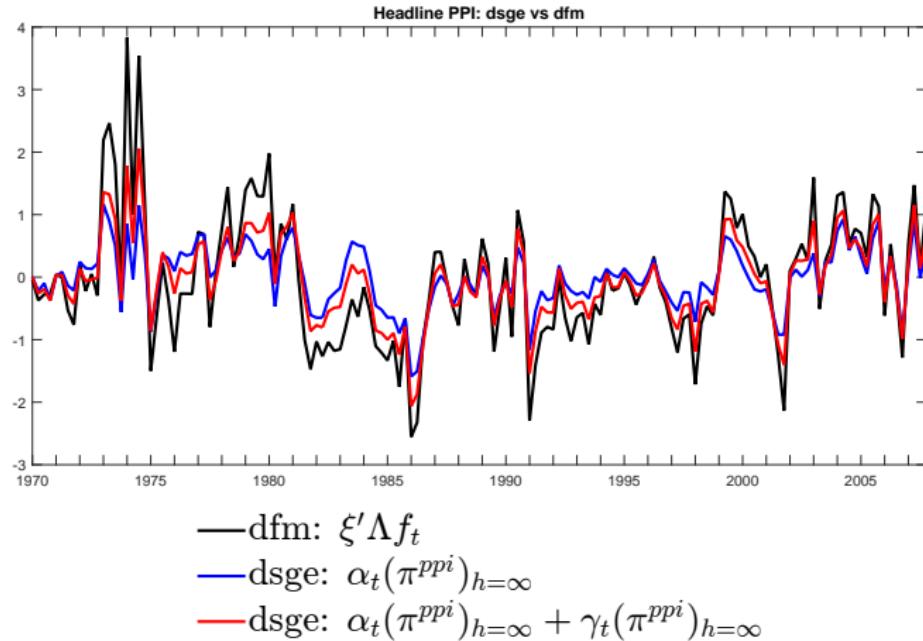
# Comparison dfm vs. structural model

- Decompose U.S. inflation
  - Factor model:  $\pi_{it} = \boldsymbol{\lambda}'_i \mathbf{f}_t + \epsilon_{it}$
  - Structural model:  $\pi_{it} = \boldsymbol{\alpha}_t(\pi_i) + \boldsymbol{\beta}_t(\pi_i) + \boldsymbol{\gamma}_t(\pi_i)$



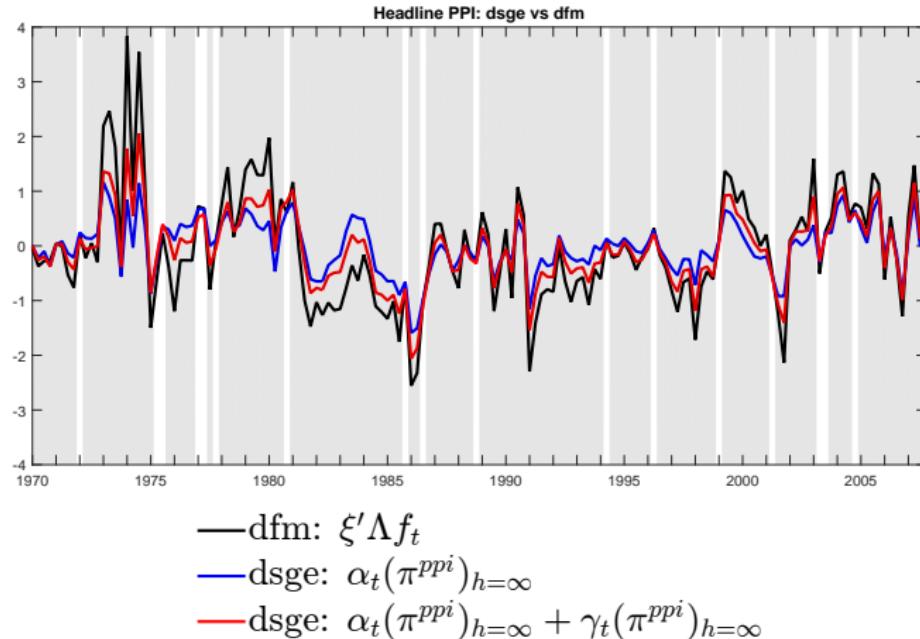
# Comparison dfm vs. structural model

- ▶ Decompose U.S. inflation
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# Comparison dfm vs. structural model

- Decompose U.S. inflation
  - Factor model:  $\pi_{it} = \boldsymbol{\lambda}'_i \mathbf{f}_t + \epsilon_{it}$
  - Structural model:  $\pi_{it} = \boldsymbol{\alpha}_t(\pi_i) + \boldsymbol{\beta}_t(\pi_i) + \boldsymbol{\gamma}_t(\pi_i)$



# Volatility & Persistence (iii): Volatility

## FORECAST ERROR VARIANCE DECOMPOSITION: PRODUCER PRICES

$$\pi_{jt} = \alpha_t(\pi_j) + \beta_t(\pi_j) + \gamma_t(\pi_j)$$

	Infinite horizon ( <i>FEVD</i> ( $\infty$ ))			<i>FEVD</i> (1)
	Macro	Micro		<b>Micro</b>
		Direct	Pipeline Pressures	Pipeline Pressures
	(1)	(2)	(3)	(4)
Agriculture & Forestry	5.46	93.68	0.86	0.73
Oil and gas extraction	4.28	92.25	3.47	3.12
Mining, except oil and gas	7.90	90.98	1.12	0.74
Utilities	14.84	81.33	3.83	3.37
Construction	54.90	38.92	6.18	4.03
Computer and electronic products	26.75	70.91	2.34	1.28
Electrical equipment, and appliances	31.07	64.68	4.25	2.98
Motor vehicles, bodies and trailers	28.91	69.46	1.63	1.37
Furniture and related products	30.77	64.51	4.72	2.96
Petroleum and coal products	23.01	36.74	40.25	41.25
Chemical products	26.23	65.32	8.45	4.56
Plastics and rubber products	29.32	67.70	2.97	2.00
Wholesale trade	45.49	30.13	24.38	12.59
Transportation and warehousing	43.20	51.84	4.97	3.44
Information	43.09	41.79	15.11	8.17
FIRE	46.36	41.79	11.85	8.04
PROF	35.53	54.61	9.86	4.59
EHS	34.65	53.79	11.57	5.9
Headline inflation	69.09	9.43	21.47	12.16

# Volatility & Persistence (iii): Volatility

## FORECAST ERROR VARIANCE DECOMPOSITION: PRODUCER PRICES

$$\pi_{jt} = \alpha_t(\pi_j) + \beta_t(\pi_j) + \gamma_t(\pi_j)$$

	Infinite horizon ( <i>FEVD</i> ( $\infty$ ))			<i>FEVD</i> (1)
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Direct sectoral shocks are most important for disaggregate inflation volatility

# Volatility & Persistence (iii): Volatility

## FORECAST ERROR VARIANCE DECOMPOSITION: PRODUCER PRICES

$$\pi_{jt} = \alpha_t(\pi_j) + \beta_t(\pi_j) + \gamma_t(\pi_j)$$

	Infinite horizon ( <i>FEVD</i> ( $\infty$ ))			<i>FEVD</i> (1)
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Aggregate shocks are of second order importance for disaggregate inflation volatility.

# Volatility & Persistence (iii): Volatility

## FORECAST ERROR VARIANCE DECOMPOSITION: PRODUCER PRICES

$$\pi_{jt} = \alpha_t(\pi_j) + \beta_t(\pi_j) + \gamma_t(\pi_j)$$

	Infinite horizon ( <i>FEVD</i> ( $\infty$ ))			<i>FEVD</i> (1)
	Macro	Micro		Micro
		Direct	Pipeline Pressures	Pipeline Pressures
	(1)	(2)	(3)	(4)
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Pipeline pressures are of second order importance for disaggregate inflation volatility (heterogeneity).

# Volatility & Persistence (iii): Volatility

## FORECAST ERROR VARIANCE DECOMPOSITION: PRODUCER PRICES

$$\pi_{jt} = \alpha_t(\pi_j) + \beta_t(\pi_j) + \gamma_t(\pi_j)$$

	Infinite horizon ( <i>FEVD</i> ( $\infty$ ))			<i>FEVD</i> (1) Micro
	Macro		Micro	
	(1)	Direct	Pipeline Pressures	
Agriculture & Forestry	5.46	93.68	0.86	0.73
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Pipeline pressures take time to materialize

# Volatility & Persistence (iii): Volatility

## FORECAST ERROR VARIANCE DECOMPOSITION: PRODUCER PRICES

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Aggregate shocks are most important for headline inflation volatility

# Volatility & Persistence (iii): Volatility

## FORECAST ERROR VARIANCE DECOMPOSITION: PRODUCER PRICES

$$\pi_{jt} = \alpha_t(\pi_j) + \beta_t(\pi_j) + \gamma_t(\pi_j)$$

	Infinite horizon ( <i>FEVD</i> ( $\infty$ ))			<i>FEVD</i> (1)
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Direct effect of sectoral shocks average out

# Volatility & Persistence (iii): Volatility

## FORECAST ERROR VARIANCE DECOMPOSITION: PRODUCER PRICES

$$\pi_{jt} = \alpha_t(\pi_j) + \beta_t(\pi_j) + \gamma_t(\pi_j)$$

	Infinite horizon ( <i>FEVD</i> ( $\infty$ ))			<i>FEVD</i> (1)
	Macro	Micro		Micro
		Direct	Pipeline Pressures	Pipeline Pressures
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EHS	34.65	53.79	11.57	5.9
Headline inflation	69.09	9.43	21.47	12.16

Stylized fact 2: Pipeline pressures are important due to comovement

# Volatility & Persistence (iii): Volatility

FORECAST ERROR VARIANCE DECOMPOSITION: CONSUMER PRICES

$$\pi_{zt} = \alpha_t(\pi_z) + \beta_t(\pi_z) + \gamma_t(\pi_z)$$

	Infinite horizon ( <i>FEVD</i> ( $\infty$ ))			<i>FEVD</i> (1) Micro Pipeline Pressures
	Macro		Micro	
	Macro	Direct	Pipeline Pressures	
	(1)	(2)	(3)	(4)
Motor vehicles and parts	19.76	42.98	37.26	36.96
Furnishings and durable hh equipment	14.00	76.47	9.53	5.23
Recreational goods and vehicles	15.85	71.19	12.95	8.2
Other durable goods	13.96	74.85	11.19	5.53
Food and beverages PFOPC	12.31	57.48	30.21	28.94
Clothing and footwear	12.12	60.85	27.03	25.65
Gasoline and other energy goods	10.04	68.35	21.61	20.27
Other nondurable goods	10.91	79.1	9.99	6.06
Housing and utilities	20.89	57.63	21.48	18.54
Health care	38.65	18.1	43.25	35.07
Transportation services	21.45	63.2	15.35	10.99
Recreation services	29.57	41.2	29.23	17.87
Food services and accommodations	23.64	43.18	33.18	23.68
Financial services and insurance	32.83	28.2	38.97	30.93
Other services	26.63	50.64	22.72	12.52
NPISHs	20.53	60.92	18.55	10.34
Public Sector	9.33	4.12	86.55	84.05

## Volatility & Persistence (ii): Persistence

PERSISTENCE DECOMPOSITION  $\pi_{jt}^{ppi} = \alpha_t(\pi_j^{ppi}) + \beta_t(\pi_j^{ppi}) + \gamma_t(\pi_j^{ppi})$

	Macro		Micro	
			Direct	Pipeline Pressures
	(1)	(2)	(3)	
$\rho(\alpha_t(\pi^{ppi}))$		$\rho(\beta_t(\pi^{ppi}))$		$\rho(\gamma_t(\pi^{ppi}))$
$\pi_t^{ppi}$	0.332	0.080	0.793	
$\rho(\alpha_t(\pi_j^{ppi}))$		$\rho(\beta_t(\pi_j^{ppi}))$		$\rho(\gamma_t(\pi_j^{ppi}))$
$\pi_{jt}^{ppi}$	Average	0.335	0.066	0.635
	Median	0.379	0.115	0.719

## Volatility & Persistence (ii): Persistence

PERSISTENCE DECOMPOSITION  $\pi_{jt}^{ppi} = \alpha_t(\pi_j^{ppi}) + \beta_t(\pi_j^{ppi}) + \gamma_t(\pi_j^{ppi})$

	Macro	Micro	
	(1)	Direct	Pipeline Pressures
$\pi_t^{ppi}$	$\rho(\alpha_t(\pi^{ppi}))$	$\rho(\beta_t(\pi^{ppi}))$	$\rho(\gamma_t(\pi^{ppi}))$
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1. Stylized fact 1 and 3: Aggregate shocks: persistence

## Volatility & Persistence (ii): Persistence

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	Macro	Micro	
	(1)	Direct	Pipeline Pressures
	$\rho(\alpha_t(\pi^{ppi}))$	$\rho(\beta_t(\pi^{ppi}))$	$\rho(\gamma_t(\pi^{ppi}))$
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	$\rho(\alpha_t(\pi_j^{ppi}))$	$\rho(\beta_t(\pi_j^{ppi}))$	$\rho(\gamma_t(\pi_j^{ppi}))$
$\pi_{jt}^{ppi}$	Average	0.335	0.635
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1. Stylized fact 1 and 3: Aggregate shocks: persistence
2. Stylized fact 1 and 3: Direct effect of sectoral shocks: no persistence

## Volatility & Persistence (ii): Persistence

PERSISTENCE DECOMPOSITION  $\pi_{jt}^{ppi} = \alpha_t(\pi_j^{ppi}) + \beta_t(\pi_j^{ppi}) + \gamma_t(\pi_j^{ppi})$

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	(1)	Direct	Pipeline Pressures
$\rho(\alpha_t(\pi^{ppi}))$	0.332	0.080	0.793
$\pi_t^{ppi}$			
$\rho(\alpha_t(\pi_j^{ppi}))$	0.335	0.066	0.635
$\pi_{jt}^{ppi}$	Average		
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1. Stylized fact 1 and 3: Aggregate shocks: persistence
2. Stylized fact 1 and 3: Direct effect of sectoral shocks: no persistence
3. Stylized fact 1 and 3: Pipeline pressures: persistence

## Volatility & Persistence (ii): Persistence

PERSISTENCE DECOMPOSITION  $\pi_{zt}^{pce} = \alpha_t(\pi_z^{pce}) + \beta_t(\pi_z^{pce}) + \gamma_t(\pi_z^{pce})$

		Macro	Micro	
			Direct	Pipeline Pressures
		(1)	(2)	(3)
		$\rho(\alpha_t(\pi^{pce}))$	$\rho(\beta_t(\pi^{pce}))$	$\rho(\gamma_t(\pi^{pce}))$
$\pi_t^{pce}$		0.570	0.275	0.901
		$\rho(\alpha_t(\pi_z^{pce}))$	$\rho(\beta_t(\pi_z^{pce}))$	$\rho(\gamma_t(\pi_z^{pce}))$
$\pi_{zt}^{pce}$	Average	0.711	0.176	0.865
	Median	0.780	0.151	0.899

# Additional results (i): Origins of pipeline pressures

## PIPELINE PRESSURE DECOMPOSITION: INFINITE HORIZON

	Agriculture & Forestry	Oil & gas extraction	Construction	Machinery	Computer & electronics	Motorized vehicles	Wholesale trade	FIRE	PROF
<b>Producer prices</b>									
Utilities	02.37	52.82	02.19		02.02	02.47	01.33	10.88	06.48
Motor vehicles, bodies and trailers	02.30	01.21	02.72	28.05	08.56	12.37	02.46	09.62	06.37
Food and beverage and tobacco products	92.77							01.34	01.10
Petroleum and coal products		97.03							
Wholesale trade	05.15	02.09	05.80	01.61	05.87	05.78		22.31	14.09
Retail	06.11	01.79	06.23	01.53	05.65	05.59	03.58	21.95	12.44
EHS	06.65	01.86	04.67	01.27	04.40	04.67	03.12	22.65	12.91
<b>Consumer prices</b>									
Furnishings and durable hh equipment	03.56	01.22	02.82	02.19	03.91	03.36	02.61	11.63	06.62
Gasoline and other energy goods		51.35						01.37	
Health care	02.54		04.99	01.09	04.77	04.35	02.68	14.03	07.65
Recreation services	06.32	01.09	04.15	01.01	03.84	03.85	02.42	15.17	10.16
Transportation services	01.94	01.78	01.83		01.69	01.77	01.34	17.48	04.76

# Additional results (i): Origins of pipeline pressures

## PIPELINE PRESSURE DECOMPOSITION: INFINITE HORIZON

	Agriculture & Forestry								
		Oil & gas extraction		Construction	Machinery	Computer & electronics			
							Motorized vehicles	Wholesale trade	
Producer prices									
Utilities	02.37	52.82	02.19		02.02	02.47	01.33	10.88	06.48
Motor vehicles, bodies and trailers	02.30	01.21	02.72	28.05	08.56	12.37	02.46	09.62	06.37
Food and beverage and tobacco products	92.77							01.34	01.10
Petroleum and coal products		97.03							
Wholesale trade	05.15	02.09	05.80	01.61	05.87	05.78		22.31	14.09
Retail	06.11	01.79	06.23	01.53	05.65	05.59	03.58	21.95	12.44
EHS	06.65	01.86	04.67	01.27	04.40	04.67	03.12	22.65	12.91
Consumer prices									
Furnishings and durable hh equipment	03.56	01.22	02.82	02.19	03.91	03.36	02.61	11.63	06.62
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Role of Input-output structure is apparent

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## PIPELINE PRESSURE DECOMPOSITION: INFINITE HORIZON

	Agriculture & Forestry	Oil & gas extraction	Construction	Machinery	Computer & electronics	Motorized vehicles	Wholesale trade	FIRE	PROF
Producer prices									
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Role of service sector: important

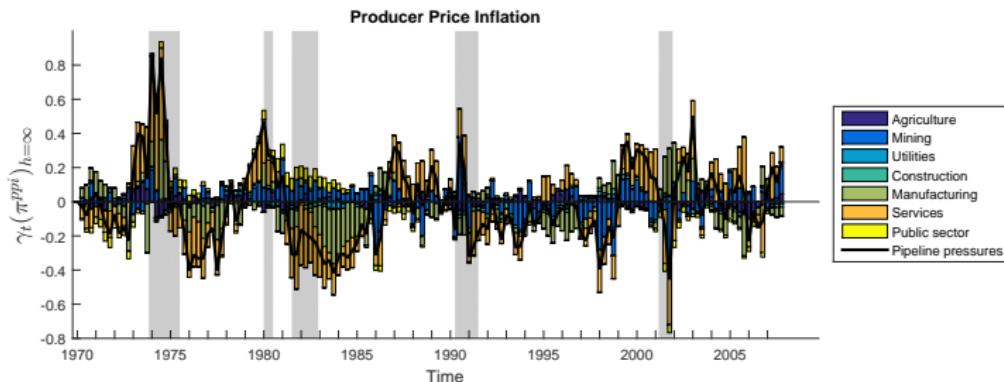
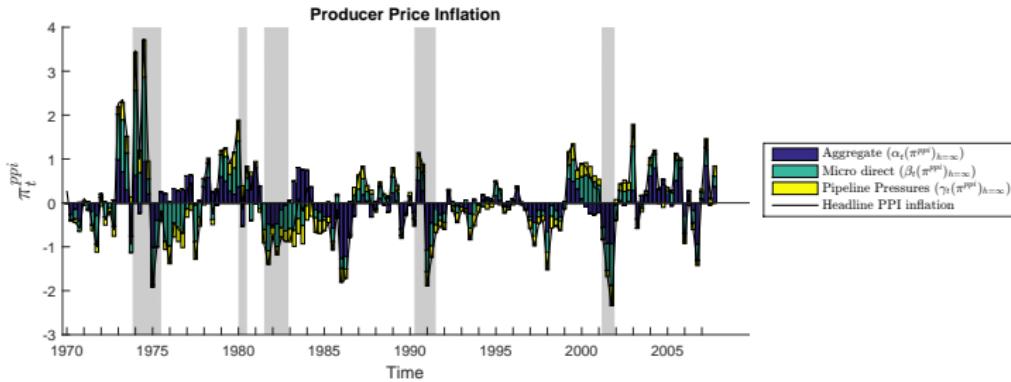
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## PIPELINE PRESSURE DECOMPOSITION: INFINITE HORIZON

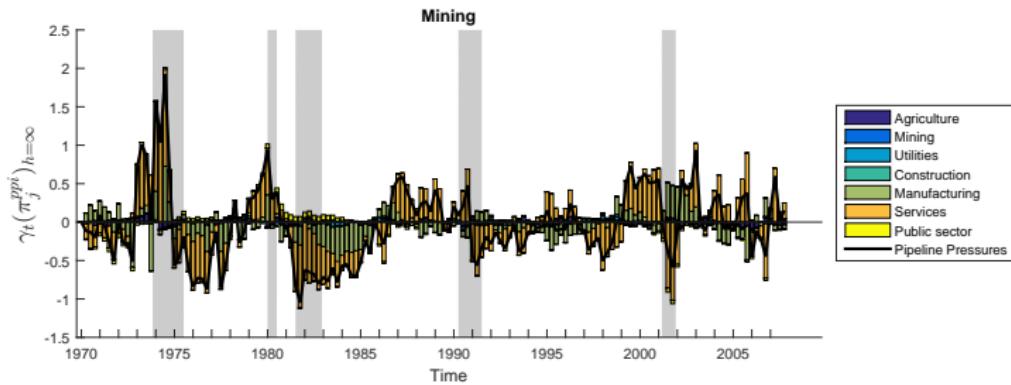
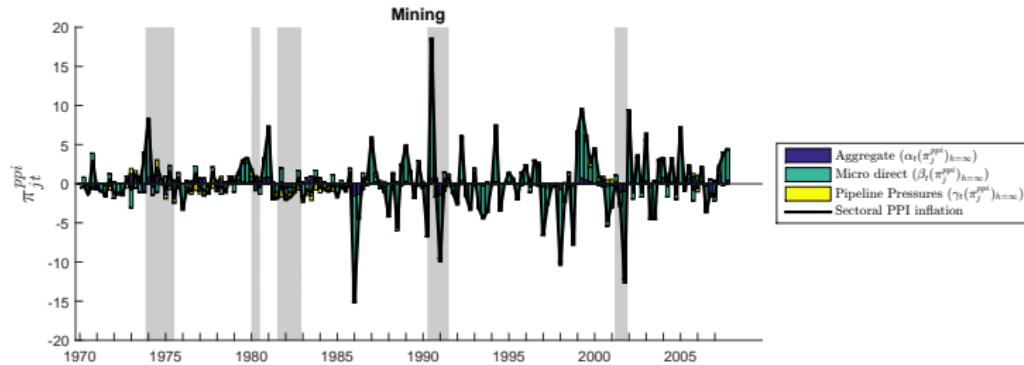
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Role of investment flows is important

## Additional results (ii): Historical “Mechanism” decomposition



## Additional results (ii): Historical “Mechanism” decomposition



# Plan

Motivation

What do we know so far?

The model

Overview of the model

Estimation details

Results

Test prevalence pipeline pressures

Comparison dfm vs. structural model

Volatility & Persistence

Additional results

Concluding remarks

# Concluding remarks

## This paper

1. Studied the role of pipeline pressures for inflation volatility and persistence.
2. Benchmarked with traditional dfm framework

## Policy implications

1. Useful framework to study sector-specific policy interventions.
  - ▶ E.g., Healthcare sector regulation (e.g. Affordable Care Act, NEJM 2014)
  - ▶ Telecommunications sectors (ECB, 2011)
  - ▶ Shale gas boom in the mining sector (Weijermans, 2013)
  - ▶ ...
2. Subdued inflation
3. Improve forecasting: a production view

## Road ahead

1. Strategic complementarities
2. International trade
3. Application to EU/Belgium